

A Rapidly Relocatable, Coupled, Mesoscale Modeling System for Naval Special Warfare

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LONG-TERM GOALS

This project is one coordinated component of a larger combined 6.2/6.4 Rapid Transition Project (RTP) to address specific Naval Special Warfare (NSW) operational decisions that are affected by meteorology and oceanography (METOC) processes. Our overall goal is to develop technology for a unique, rapidly globally-relocatable, coupled air-sea, high-resolution data assimilation system capable of optimally utilizing the diverse, highly perishable, on-scene environmental data collected by NSW forces for improved forecasts and characterizations of the impact of rapidly changing, operationally significant environmental situations.

OBJECTIVES

The specific objectives of this project within the larger effort are: 1) to design and develop the prototype coupled air-sea modeling and data assimilation capability within the existing Naval Research Laboratory (NRL) Coupled Ocean/Atmosphere Mesoscale Prediction System – On Scene (COAMPS-OS[®]) system, including a “smart,” automatically-adaptive Graphical User Interface (GUI) for easy set-up of the coupled system; 2) to invent the data acquisition and processing software necessary to utilize the variety of NSW collected data, including oceanographic, atmospheric, and bathymetric observations; and 3) to obtain end-user buy-in through a series of verification and validation experiments that include NSW-relevant scenarios and operations.

APPROACH

Utilizing the NSW Mission Support Center (MSC) as a beta test facility, we will invent, test, and implement a unique strategy for coupling atmospheric and oceanographic models and for assimilation of METOC data from NSW sensors in near real time within the framework provided by COAMPS-OS. Our strategy allows for demonstrating operational support while at the same time providing a technology that can be scaled to larger systems and transitioned to Production Centers, i.e. Fleet Numerical Meteorology and Oceanography Center (FNMOC) if appropriate.

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To meet the challenge of utilizing METOC data available at asynoptic times collected by forward-deployed NSW units, COAMPS-OS will be significantly enhanced to support an integrated ocean 3-dimensional analysis system (Navy Coupled Ocean Data Assimilation; NCODA), and an ocean model (Navy Coastal Ocean Model; NCOM); in the future we plan to implement an integrated shallow-water wave modeling capability as well (Simulating Waves Near-shore; SWAN). Initially, NCODA and NCOM will be integrated into the COAMPS-OS software suite and the existing COAMPS GUI will be enhanced to control the oceanographic domain and other ocean model and data assimilation parameters. New interfaces will have to be invented to access and quality control ocean observations from both Central Site and local NSW sensors. Software to access and process lateral boundary conditions from a global ocean model will also be developed to support the limited area NCOM forecast model. Additionally, in collaboration with the NSW warfighters at the MSC, we will develop automated output products from the system that are tailored to mission requirements. These forecast products will be evaluated with data from the information-rich Southern California area, leveraging Intensive Observing Periods (IOP) for other experiments and NSW training operations. We view the success of this project to be directly related to acceptance by the end-users. Without a feedback mechanism between the S&T process and the end-users, it is possible to be scientifically and technically correct, but produce results that are not useful.

Another key element of our approach is to leverage other projects at NRL. NRL is already established as a leader in the development of high-resolution atmospheric and ocean models, and air-ocean coupling. The atmospheric component of COAMPS has established itself as a state-of-the-art mesoscale model, providing high-resolution (as low as 2 km grid spacing) guidance for many regions over the earth. The NRL NCOM ocean model was developed in a joint ONR-sponsored program with NRL Stennis Space Center (NRL SSC). NRL Monterey (NRL MRY) is now running NCOM in a one-way coupled mode in a near-real time application over the Mediterranean, while NRL SSC is testing the relocatability of NCOM to various other geographic locations (e.g., East Asian Seas). Our approach is to merge these two components of the mesoscale simulation systems into one coherent system to explore the physics of air-ocean interactions important for NSW operations.

This project is in direct support of the Oceanographer of the Navy's (N7C) Littoral Battlespace Sensor Fusion and Integration initiative.

WORK COMPLETED

A Workshop on Oceanographic Studies in the SOCAL area was held at Scripps Institute of Oceanography to identify ongoing and planned oceanographic studies that can be used for testing the coupled modeling system. A coordination workshop was held at NRL MRY to discuss the coupled modeling tools and approaches. The coupling strategy was defined and software to provide COAMPS data for NCOM was developed. NCODA (Message Passing version) was installed and tested and software development for the interface to NCOM was begun. Initial modifications to the COAMPS-OS GUI were developed to accommodate NCOM. A small (24 processors) LINUX cluster was procured and set up at NRL MRY for model integration, software development, and verification testing and evaluation. Figure 1 shows the sea surface temperature analysis results from NCODA-MPI for a San Diego regional (5-km) ocean domain designed for testing NCOM and COAMPS coupling. In the fall of 2005, the first iteration of the prototype integrated system will be completed and available for benchmarking and testing the one-way coupled system.

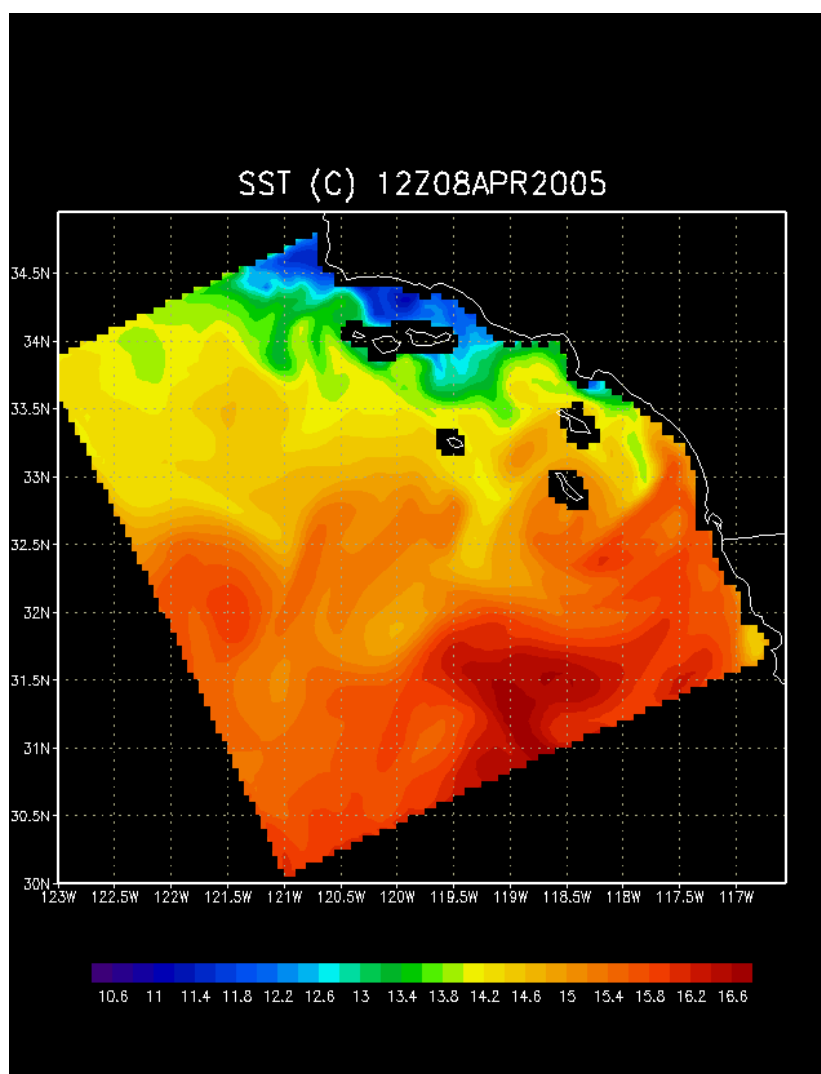


Fig. 1. NCOM/NCODA coarse regional mesh (5 km horizontal grid spacing) running on the prototype LINUX cluster system.

RESULTS

The scientific and technical challenges of developing a unique, globally-relocatable, coupled air-ocean data assimilation and forecasting system are daunting, particularly while trying to coordinate with multiple groups of scientists and trying to focus the operational support on relevant issues to the NSW warfighter. The NSW operational requirements of 1 km horizontal resolution (requiring approximately 250m grid spacing) and 5h nowcasts to 96h forecasts will not be realized in the near future. Based on what we discover as we plow this ground, our goals are to prototype the system and demonstrate enhanced capability. Issues identified and recommended solutions for data collection and connectivity (communications) and security (both opsec and information technology) will need to be addressed by the broader Navy METOC operational community.

IMPACT/APPLICATIONS

NSW operations are optimally supported by dedicated mesoscale atmospheric and oceanographic modeling responsive to temporal and spatial requirements. NSW forces operate and employ platform/vehicles, weapons, and sensors especially sensitive to the environment – both atmospheric and oceanographic. NSW operations are focused on small geographic areas for short duration. Rapid spin-up of globally relocatable models and production of model data to the forecasters over relatively short time frames is important. Mission analysis and execution benefit from high resolution atmosphere and oceanographic modeling that accurately characterizes and forecasts the battlespace and distributes the important information to NSW systems.

Thresholded atmospheric and oceanographic requirements for NSW operations and platforms/vehicles are documented in SOCOM Directive 525-6 and Naval Special Warfare Mission Planning guides. High-resolution modeling coupled with the NSW Business Line Manager initiative to deploy sensors (via Environmental Reconnaissance Teams) with data accessible from the MSC, will improve the accuracy of high resolution forecasts supporting NSW operations. Model experts present in the MSC will allow for the input into the deployment of METOC sensors to best support the models. In addition, specific lessons learned from combat operations in support of Operations Iraqi Freedom and Enduring Freedom and more recent combat operations highlight the shortfall that exists today in the absence of dedicated coupled mesoscale modeling. Tactical Decision Aids (TDAs), such as the Advanced Refractive Effects Prediction System (AREPS) and the Target Acquisition Weapons Software (TAWS), are used to support NSW operations and will benefit from the increased resolution and accuracy of high resolution model data. Coupling of atmospheric and oceanographic models will also provide more accurate waves in the near-shore area using the wave model SWAN. The MSC is a supportive environment for beta-testing systems and can provide an ample opportunity to demonstrate technologies and capabilities in multiple exercises and operations.

RELATED PROJECTS

There are several related projects in air-ocean coupling at NRL MRY:

Battlespace Environmental Assessment for Situational Awareness [PI: Cook – NRL Base] addressing development of a coupled air-ocean data assimilation capability.

Air-Ocean Coupling in the Coastal Zone [PI: Pullen – NRL Base 6.1] addressing basic research issues related to the identification and understanding the interaction between the ocean and the atmosphere in the littoral region.

Assessing the Effectiveness of Sub-mesoscale Ocean Parameterizations (AESOP) [PI: Hodur – ONR DRI] studying sub-mesoscale parameterizations for high-resolution (regional scale) models with a strong focus on multi-scale interactions and acquisition of new field data.

Hybrid Coordinate Ocean Model (HYCOM) [PI: Hodur/Pullen - NOPP] developing and evaluating a hybrid isopycnal-sigma pressure (generalized) coordinate ocean model, including data assimilation.

Battlespace Environments Institute (BEI) [PI: Hodur – CHSSI 6.3] migrating existing DoD atmosphere, ocean, and space modeling applications to the Earth System Modeling Framework (ESMF) and assisting in transitioning non-DoD ESMF applications to DoD.

Littoral Warfare Team Adaptive Sampling Integration [PI: Bishop - RTP] developing and transitioning the capability to the Naval Oceanographic Office (NAVO) to utilize adaptive sampling to improve predictions of sound speed velocity fields for Anti-Submarine Warfare (ASW).

Coastal Ocean Currents Monitoring Program – Northern and Central California (COCMP-NC) [PI: Doyle – California State through USF] monitoring ocean circulation for the region between Pt. Conception and the California/Oregon border using a combination of Surface Current Mapping (SCM) instruments and both 3-D coastal ocean and 2-D San Francisco Bay circulation models.